

## Description

# A SYSTEM AND METHOD FOR EXECUTING INTERACTIVE APPLICATIONS WITH MINIMAL PRIVILEGES

### FIELD OF THE INVENTION

[0001] The illustrative embodiment of the present invention relates generally to the running of interactive applications in an application-specific execution environment with a determined set of minimal privileges based on criteria determined by a policy-based decision system, and more particularly to the execution of applications with minimal privileges in a distributed application environment.

### BACKGROUND OF THE INVENTION

[0002] The principle of least privilege is a well-known secure computing aim but is difficult to achieve in practice. An application should run with the minimal set of permissions/privileges required for its tasks. Permissions/privileges for an application include the ability to read, write,

and display other data and/or launch other applications and processes. Operating systems typically run applications under the user account of the logged-in user and the user account is forced to trust the application with all of the rights that the user holds regardless of whether or not they are necessary to run the application. The operating system is typically responsible for provisioning user accounts. Provisioning an account includes setting up the rights of the user and verifying the user identity by calling an appropriate credential/identity mapping process. The account provisioning process is usually performed on a per-user basis. That is, the rights and privileges the logged-in user holds are automatically assigned to the requested application. This is a problem for home users who are typically listed as system administrators and for systems administrators, developers and others in a corporate environment who possess broad privileges for at least two reasons.

[0003] First, an application which is completely "trusted" ends up with potentially unlimited access to other data and applications (limited only by the extent of the user's privileges). Unlimited access for an application is a problem even in the event that the requested application is not itself per se

malicious, as the application may still cause buffer overruns, SQL injections, or be manipulated by hackers who cause intentional problems.

[0004] Second, when an application has unlimited access rights, the auditing of events occurring in a system becomes complicated since it is difficult to prove that the application did not perform an action (since the application could have performed the action). Acceptable auditing of the execution environments in which an application is to run is required for banking, medical and other applications requiring secure execution. Conventional methods of limiting access rights of an application such as running the application as a web application (which may need to be re-written) in a common (often unprivileged) operating system account, or using the origin of the code as the basis of deciding if permission is to be granted suffer from an inability to restrict users to their own data or only controlling permissions above the operating system level, respectively.

## **BRIEF SUMMARY OF THE INVENTION**

[0005] The illustrative embodiment of the present invention provides a mechanism for running interactive applications with a minimal set of privileges. The privileges form a

subset or superset of the privileges afforded to the user requesting the application and are allocated consistent with the principle of least privilege. The principle of least privilege ensures that an application runs with the minimal amount of permissions necessary to accomplish its assigned tasks. A new user account is created and provisioned or a pre-existing account is identified for each application to which a user requests access. The accounts have a subset/superset of the access rights and operating system privileges that the user who is logged on to the system and requesting access to the application ordinarily enjoys. Server-based applications run in this application-specific execution environment/operating system accounts and display output to users via ICA or RDP.

[0006] The subset/superset of the user's privileges (referred to hereafter as "thin privileges") is determined by a policy-based decision system. The policy-based decision system may be implemented as a rule or logic-based system and/or may use scripted agents. The policy-based decision system is used to map a request to run an application to an operating system account created or identified for the application. The policy-based decision system makes its determination of thin privileges based on an analysis of

the application requirements, an analysis of the data security and privacy concerns associated with the execution of the application, the identity of the user and user's role and any other policy considerations indicated by an administrator. Once the determination as to the appropriate set of privileges to be afforded to the application in the execution environment has been made, the execution environment is created and provisioned or a pre-existing execution environment possessing the requisite privileges is identified and the remote user is logged into the server-side account. In one aspect of the present invention, the user does not have to provide her username/password as the log-on is automatic. The application specific accounts may be audited by audit trail tools that document the operating system account provisioning and provide evidence of policy enforcement.

[0007] In one embodiment, a method provides secure access to applications. The method includes the step of receiving a request from a user to execute an application. The method also includes the step of determining a minimal set of computing privileges necessary for the user to use the requested application. The method for providing secure access to applications further includes the step of in-

voking an execution environment for the user that enables the application to execute with the determined set of privileges.

[0008] In another embodiment, an application server system provides secure access to hosted applications. The system includes a policy based decision system that receives a request from a user to execute an application. The policy based decision system determines a minimal set of privileges required by the user to execute the application. The system further includes an account administration service that is in communication with the policy based decision system. The account administration service invokes or creates an execution environment for the user that has the determined set of minimal privileges.

## **BRIEF DESCRIPTION OF THE DRAWINGS**

[0009] These and other aspects of this invention will be readily apparent from the detailed description below and the appended drawings, which are meant to illustrate and not to limit the invention, and in which:

[0010] Figure 1 depicts an environment suitable for practicing the illustrative embodiment of the present invention;

[0011] Figure 2A is a block diagram depicting a typical computer useful in the present invention;

- [0012] Figure 2B depicts an embodiment of the computer system in which the processor communicates directly with main memory via a memory port;
- [0013] Figure 3 is a flow chart of the sequence of steps followed by the illustrative embodiment of the present invention to create application-specific execution environments based on thin privileges of the application;
- [0014] Figure 4 is a flow chart of the sequence of steps followed by the illustrative embodiment of the present invention to utilize the policy-based decision system; and
- [0015] Figure 5 is a flow chart of the sequence of steps followed by the illustrative embodiment of the present invention to apply a variety of policy parameters in creating/identifying application-specific execution environments.

## **DETAILED DESCRIPTION OF THE INVENTION**

- [0016] The illustrative embodiment of the present invention provides a mechanism for executing applications while adhering to the principle of least privilege. An application-specific operating system account is created or identified for each application that a user is required to employ securely. The accounts have a subset/superset of the access rights and operating system privileges to which the requesting user is entitled. The subset/superset of access

rights or "thin privileges" is based on a number of factors determined by a policy-based decision system. The policy-based decision system may be rule or logic based or employ scripted agents and is used to map a request to run an application to a specially created or identified operating system account. The policy-based decision system analyzes application requirements, data security, and privacy concerns, and any other policy considerations noted by the administrator, and then interacts with the operating system to find or create and provision an operating system account for the application. The policy-based decision system also launches an ICA or RDP application that includes CITRIX PASSWORD MANAGER from Citrix Systems, Inc. of Fort Lauderdale, Florida, or similar credential/ identity mapping technology to log the remote user into the specially created or identified server-side account. Alternatively the OS can perform the login automatically. For example, Unix has an "su", superuser command, which allows trusted processes to transition to an arbitrary user account. The special accounts may be audited so as to provide trustable evidence for policy enforcement and verification.

[0017] The principle of least privilege and the illustrative embod-



iment of the present invention are also applicable to a distributed networking environment where a remotely logged in user requests the application. Technologies for providing remote access to networked resources include a variety of client/server software combinations. One of these combinations is often referred to as a "thin-client" system. In these systems, an application is executed by a server computing device, usually referred to as the "application server," on behalf of one or more client computing devices, usually referred to as the "thin-client" or the "thin-client application." Only input to the application received from the user at the thin-client is transmitted from the thin-client to the application server and only output produced by an application executing on the application server is transmitted from the application server to the thin-client. The server side application may also be granted access to other client side resources, such as disks, based on "thin" privilege" principles.

[0018] Thin-client computing architectures are popular implementations for providing remote connectivity to applications and other system resources. Examples of such systems include: CITRIX METAFRAME PRESENTATION SERVER software in combination with Intelligent Computing Archi-

itecture (ICA) clients, available from Citrix Systems, Inc.; X servers in combination with X Windows clients available from the X Consortium; and Microsoft Windows NT Server 4.0 Terminal Server Edition in combination with Remote Display Protocol (RDP) clients, available from Microsoft Corporation of Redmond, Washington. It is possible to run all the components identified above (Thin-client; ICA protocol; App Server) on one computing device. This provides the advantages of secure application execution using minimal privileged principles to a single system, co-located with the user. The policy decision component can be broken out in order to provide centralized management, for example, for applications deployed on desktop PCs in a corporate environment.

[0019] Figure 1 depicts an environment suitable for practicing the illustrative embodiment of the present invention. An application server 2 and client system 44 are both interfaced with a network 40. The network 40 may be a wide area network (WAN) such as the Internet, a metropolitan area network (MAN), local area network (LAN), an intranet, or some other type of network. The client system 44 may be a thin client. A user 46 accesses the network 40 via the client system 44. An administrator 42 also accesses the

network 40 via an electronic device 41. The application server 2 includes a policy based decision system 4, applications 6, 8, 10, an account administrative service 12, a connection manager 14, and execution environments 16, 18, and 20. Although only three execution environments 16, 18 and 20 are shown in Figure 1, those skilled in the art will recognize that a greater or lesser number of execution environments may also be created on-demand without departing from the scope of the present invention. Similarly, the policy based decision system 4 may be centralized as a secure service shared between application servers or be located at another location accessible to the application server 2 without departing the scope of the present invention.

[0020] The policy based decision system 4 determines the minimal set of privileges required by the user to execute the application 6, 8 and 10 requested by the user. The account administration service 12 contacts the policy based decision system 4 and invokes the execution environment 16, 18 and 20 for the user which have the determined set of thin privileges being afforded to the applications. The invoked execution environments 16, 18 and 20 may be created and provisioned consistent with the determined

set of thin privileges afforded the application or may be identified as an existing execution environment suitable for the application. In one implementation of the present invention, each application gets put into one and only one execution environment. In another implementation, multiple applications can share the same execution environment. Applications 6, 8, and 10 are programs that may be requested by the user 46. The connection manager 14 is also in communication with the policy based decision system 4 and transmits to the policy based decision system an identification of the user 46 requesting a particular application.

[0021] The application server 2 also has access to a database 30. The database 30 has datasets 32, 34, and 36 that may be required by the requested application 6, 8, and 10. The datasets 32, 34, and 36 may have an individual confidentiality policy associated with the dataset such as the confidentiality policy 38 associated with dataset 32. Any confidentiality policies associated with the datasets 32, 34 and 36 may be utilized by the policy based decision system 4 in determining the privileges afforded to the application during execution.

[0022] Still referring to Figure 1 and in more detail, the policy-

based decision system 4 enforces the principle of least privilege by enforcing a companies or third party's confidentiality policies. The policy based decision system 4 is responsible for determining the "thin privileges that will be afforded to the application during execution. These thin privileges form a subset/superset of the privileges afforded to the logged in user requesting the execution of the application. In most situations, the privileges are the same as the user's privileges or a more restricted set of privileges. Those skilled in the art will recognize that if the requested application requires more extensive privileges than the requesting user possesses in order to run, the application will not be executed unless the policy based decision system 4 authorizes a superset of the user's privileges. The type of privileges afforded to the requested application restrict what the application can do for the user. Applications 6, 8 and 10 are given access only to those resources necessary for the application to function properly, such as the datasets 32, 34 and 36. For example, a word processing application may require read and write access to the file system. Another application may require a user to be able to sign a document electronically or view only a particular dataset. Additional

privileges that may be restricted include network access and IPC/RPC or shared memory. The ability to load and run code libraries may also be restricted as may access to the I/O resources depicted in Figure 2A and 2B. Similarly, the ability to make system calls and requests to other applications and services/servers are also important privileges to control. Multiple different types of applications 6, 8 and 10 may be used by the present invention such as a word processing application such as WORD from Microsoft Corporation of Redmond, Washington, or a spreadsheet application such as EXCEL also from Microsoft.

[0023] The database 30 in Figure 1 may be an SQL database, ACCESS database, ORACLE 9i database, flat file, relational database, multi-dimensional or some other type of database, or file system, disk or tape storage or shared memory. An individual confidentiality policy 38 may be may be specifically tailored for one of the datasets 32, 34 and 36. The individual confidentiality policy 38 for example may allow a dataset 32 to be read by a spreadsheet application but not written to by the spreadsheet application. The network 40 may be a wireless network, satellite network, optical network, a hybrid network, or some other type of network. The application server 2 may connect to

the network 40 through a variety of connections including standard telephone lines, LAN or WAN links (e.g., T1, T3, 56 kb, X.25), broadband connections (ISDN, Frame Relay, ATM), and wireless connections. Connections between the application server 2 and the client system 44 may use a variety of data-link layer communication protocols (e.g., TCP/IP, IPX, SPX, NetBIOS, NetBEUI, SMB, Ethernet, ARC-NET, SSL/TLS, HTTP, HTTPS, Fiber Distributed Data Interface (FDDI), RS232, IEEE 802.11, IEEE 802.11a, IEEE 802.11b, IEEE 802.11g and direct asynchronous connections).

[0024] The client system 44 which is used by the user 46 to access the network may be a desktop system, workstation, or laptop. Alternatively, the client system 44 may be a thin client such as a PDA or cellular phone with network connectivity. Figures 2A and 2B depict block diagrams of a typical computer 200 useful in the present invention. As shown in Figures 2A and 2B, each computer 200 includes a central processing unit 202, and a main memory unit 204. Each computer 200 may also include other optional elements, such as one or more input/output devices 230a-230n (generally referred to using reference numeral 230), and a cache memory 240 in communication with the

central processing unit 202.

[0025] The central processing unit 202 is any logic circuitry that responds to and processes instructions fetched from the main memory unit 204. In many embodiments, the central processing unit is provided by a microprocessor unit, such as: the 8088, the 80286, the 80386, the 80486, the Pentium, Pentium Pro, the Pentium II, the Celeron, or the Xeon processor, all of which are manufactured by Intel Corporation of Mountain View, California; the 68000, the 68010, the 68020, the 68030, the 68040, the PowerPC 601, the PowerPC604, the PowerPC604e, the MPC603e, the MPC603ei, the MPC603ev, the MPC603r, the MPC603p, the MPC740, the MPC745, the MPC750, the MPC755, the MPC7400, the MPC7410, the MPC7441, the MPC7445, the MPC7447, the MPC7450, the MPC7451, the MPC7455, the MPC7457 processor, all of which are manufactured by Motorola Corporation of Schaumburg, Illinois; the Crusoe TM5800, the Crusoe TM5600, the Crusoe TM5500, the Crusoe TM5400, the Efficeon TM8600, the Efficeon TM8300, or the Efficeon TM8620 processor, manufactured by Transmeta Corporation of Santa Clara, California; the RS/6000 processor, the RS64, the RS 64 II, the P2SC, the POWER3, the RS64 III, the POWER3-II, the RS



64 IV, the POWER4, the POWER4+, the POWER5, or the POWER6 processor, all of which are manufactured by International Business Machines of White Plains, New York; or the AMD Opteron, the AMD Athalon 64 FX, the AMD Athalon, or the AMD Duron processor, manufactured by Advanced Micro Devices of Sunnyvale, California.

[0026] Main memory unit 204 may be one or more memory chips capable of storing data and allowing any storage location to be directly accessed by the microprocessor 202, such as Static random access memory (SRAM), Burst SRAM or SynchBurst SRAM (BSRAM), Dynamic random access memory (DRAM), Fast Page Mode DRAM (FPM DRAM), Enhanced DRAM (EDRAM), Extended Data Output RAM (EDO RAM), Extended Data Output DRAM (EDO DRAM), Burst Extended Data Output DRAM (BEDO DRAM), Enhanced DRAM (EDRAM), synchronous DRAM (SDRAM), JEDEC SRAM, PC100 SDRAM, Double Data Rate SDRAM (DDR SDRAM), Enhanced SDRAM (ESDRAM), SyncLink DRAM (SLDRAM), Direct Rambus DRAM (DRDRAM), or Ferroelectric RAM (FRAM). In the embodiment shown in FIGURE 2A, the processor 202 communicates with main memory 204 via a system bus 220 (described in more detail below). FIGURE 2B depicts an embodiment of a computer system 200 in

which the processor communicates directly with main memory 204 via a memory port. For example, in FIGURE 2B the main memory 204 may be DRDRAM.

[0027] Figures 2A and 2B depict embodiments in which the main processor 202 communicates directly with cache memory 240 via a secondary bus, sometimes referred to as a "backside" bus. In other embodiments, the main processor 202 communicates with cache memory 240 using the system bus 220. Cache memory 240 typically has a faster response time than main memory 204 and is typically provided by SRAM, BSRAM, or EDRAM.

[0028] In the embodiment shown in Figure 2A , the processor 202 communicates with various I/O devices 230 via a local system bus 220. Various busses may be used to connect the central processing unit 202 to the I/O devices 230, including a VESA VL bus, an ISA bus, an EISA bus, a MicroChannel Architecture (MCA) bus, a PCI bus, a PCI-X bus, a PCI-Express bus, or a NuBus. For embodiments in which the I/O device is an video display, the processor 202 may use an Advanced Graphics Port (AGP) to communicate with the display. Figure 2B depicts an embodiment of a computer system 200 in which the main processor 202 communicates directly with I/O device 230b via Hyper-

Transport, Rapid I/O, or InfiniBand. Figure 2B also depicts an embodiment in which local busses and direct communication are mixed: the processor 202 communicates with I/O device 230a using a local interconnect bus while communicating with I/O device 230b directly.

[0029] A wide variety of I/O devices 230 may be present in the computer system 200. Input devices include keyboards, mice, trackpads, trackballs, microphones, and drawing tablets. Output devices include video displays, speakers, inkjet printers, laser printers, and dye-sublimation printers. An I/O device may also provide mass storage for the computer system 200 such as a hard disk drive, a floppy disk drive for receiving floppy disks such as 3.5-inch, 5.25-inch disks or ZIP disks, a CD-ROM drive, a CD-R/RW drive, a DVD-ROM drive, tape drives of various formats, and USB storage devices such as the USB Flash Drive line of devices manufactured by Twintech Industry, Inc. of Los Alamitos, California.

[0030] In further embodiments, an I/O device 230 may be a bridge between the system bus 220 and an external communication bus, such as a USB bus, an Apple Desktop Bus, an RS-232 serial connection, a SCSI bus, a FireWire bus, a FireWire 800 bus, an Ethernet bus, an AppleTalk bus, a

Gigabit Ethernet bus, an Asynchronous Transfer Mode bus, a HIPPI bus, a Super HIPPI bus, a SerialPlus bus, a SCI/LAMP bus, a FibreChannel bus, or a Serial Attached small computer system interface bus.

[0031] General-purpose desktop computers of the sort depicted in Figures 2A and 2B typically operate under the control of operating systems, which control scheduling of tasks and access to system resources. Typical operating systems include: MICROSOFT WINDOWS, manufactured by Microsoft Corp. of Redmond, Washington; MacOS, manufactured by Apple Computer of Cupertino, California; OS/2, manufactured by International Business Machines of Armonk, New York; and Linux, a freely-available operating system distributed by Caldera Corp. of Salt Lake City, Utah, among others.

[0032] Those skilled in the art will recognize that the illustrative embodiment of the present invention may be use a number of different types of architectures and that the modules depicted in Figure 1 may be combined in a different manner without departing from the scope of the present invention. For example, the separately shown policy based decision system 4, account administrative service 12 and connection manager 14 may be combined into a single

executable software module.

[0033] The sequence by which the policy based decision system 4 determines the "thin privileges" for the requested application is depicted in Figure 3 . The sequence of steps begins when the user requests execution of an application 6, 8, and 10 on the application server 2 (step 60). The request may be a HTTP-based request. Alternatively, the request may be an FTP request or Telnet request or proprietary protocol (such as ICA or RDP). The policy-based decision system 4 then determines the minimal set of computing privileges necessary for the user to use the requested application (i.e.: the thin privileges)(step 62). The mechanics of the policy-based decision system 4 determining the thin privileges afforded to the application are discussed in further detail below. The policy-based decision system 4 then contacts the operating system to create and provision an operating system account (also referred to herein as the execution environment 16, 18 and 20 depicted in Figure 1 ) specifically for the requested application that will have the determined set of privileges during the application execution (step 64). An ICA or RDP -based application such as CITRIX PASSWORD MANAGER from Citrix Systems, Inc., is then launched which contains credential/iden-

tity mapping technology (step 66) to map the user to the created/identified execution environment. The credentials may be supplied by the operating system. METAFRAME from Citrix Systems, Inc. and WINDOWS TERMINAL SERVICES from Microsoft Corporation may be used in this step.

[0034] Figure 4 depicts the sequence of steps followed by the illustrative embodiment of the present invention to apply a security policy to the "thin privileges" determination. The sequence begins when the administrator creates a confidentiality policy enforced by the policy based decision system 4 (step 70). The policy-based decision system 4 may be implemented via scripted agents . The scripted agents are programmable logic, written in Java/JavaScript or C/C++/C# or similar programming languages. Programmable logic is needed if the decision needs to be computed from a variety of inputs (time of day, location of user) in a complex manner (e.g. charge user's credit card). The policy-based decision system 4 may also be rule or logic based. The policy-based decision system 4 enforces policies set by the administrator 42 for the application 6, 8, and 10. The policy-based decision system 4 applies a wide variety of parameters to the process of mapping user

requested applications to a created/identified execution environment. Subsequently to the creation of the policy, the user 46 requests the execution of an application 6, 8, and 10 (step 72) and the policy-based decision system 4 determines the applicable policy parameters (step 74) as is discussed further in Figure 5 below. After the policy-based decision system 4 identifies the applicable policy parameters in the policy (step 74) the applicable policy parameters are applied in light of the request context taking into account any dynamic factors to determine the thin privileges needed (step 76). The policy-based decision system then determines whether an account already exists with the requisite thin privileges (step 78). The user is then mapped to the identified existing account (step 80) or mapped to a newly created account with the requisite thin privileges (step 82).

[0035] The policy-based decision system 4 is able to utilize a wide variety of policy parameters. For example, the parameters may specify that a word processing application should only have access to create and read/write files in a "doctor's prescriptions" file if the user is a medical practitioner at a hospital and the word processing application is being used to prescribe medication during a patient ses-

sion. Similarly, the parameters may specify that an expense report application should not be able to change source code files simply based on the identity of a user as a software developer. However, during , a code review, the parameters may specify that the developer is able to read source code and make separate notes (in another file) but not make changes (maliciously introduce bugs or back doors). Likewise, the parameters may specify that during office hours, any Web browser started can only make connections to web servers on the Intranet. The parameters may further allow the user under such a constraint to explicitly request that the browsing is done without file access privileges at all (except for some temporary files for Web caching and read-only browser configuration). Those skilled in the art will recognize that many additional types of parameters in addition to those listed herein may be utilized by the policy-based decision system 4 without departing from the scope of the present invention.

[0036] Figure 5 depicts in more detail some of the factors considered by the policy-based decision system 4 in mapping the requested application to the proper execution environment. Parameters may be dynamic such as the time of day or date and are evaluated at run-time by the policy



based decision system 4. The sequence of steps begins when the policy-based decision system 4 is activated. As previously stated the policy-based decision system may involve the execution of scripts performing various actions, and declarations and statements testing for various conditions (step 90). The policy-based decision system may involve tailoring the privileges provided to the requested application based upon the requesting user's role (step 92). For example, the amount of privileges afforded to the application may depend upon whether the user is a system operator or administrator. For example, a developer requesting an application may be afforded write privileges for the application with regard to a dataset whereas another user whose only need is to review data may be afforded only read privileges for the requested application. The policy-based decision system 4 may identify or provision a created account based on the dataset associated with the requested application (step 94). For example, if an application needs to access a particular set of data that is of a particularly confidential nature, the type of privileges granted to the application may be restricted more than in other cases where the dataset is not so important. Similarly, the policy-based decision

system 4 may allocate the privileges afforded to the requested allocation based on the application group to which the requested application belongs (step 96). For example, the type of application may control the privileges afforded to the application as per a previously set confidentiality policy. Additionally, the policy-based decision system 4 may determine specific parameters associated with an individual application (step 98). Also, dynamic variables such as the time of day and the number of users requesting an application simultaneously may be used by the determination process for allocating privileges to the application (step 100). As an example, a game application requested by a user may be permissibly executed after working hours but not during the workday. Following application of the various policy parameters, the policy-based decision system 4 arranges the mapping of the requested application to a created or identified operating system account/execution environment which is provisioned with the appropriate privileges for the application (step 102). In this manner, the applications are not blindly given the same set of user privileges afforded to the user at login.

[0037] Those skilled in the art will recognize that many additional

parameters may be identified and/or determined by the policy-based decision system 4 in the process of mapping the requested application to an identified/created account appropriate for the "thin privileges" afforded to the application. A different session is established for each application requested by users. Multiple sessions may be established for a single user at the same time. The illustrative embodiment of the present invention supports single sign on techniques where the user's login information may be relied upon to map the user into each of the unique execution environments without re-entry of the login information. Each unique execution environment supports the execution of an application with its own set of thin privileges. A unique ID referring to the execution environment is returned to the client system. The client system may use the unique ID in the presentation level protocol communications with the application server and the execution environment for the application.

[0038] Since certain changes may be made without departing from the scope of the present invention, it is intended that all matter contained in the above description or shown in the accompanying drawings be interpreted as illustrative and not in a literal sense. Practitioners of the art will real-

ize that the system configurations depicted and described herein are examples of multiple possible system configurations that fall within the scope of the current invention. Likewise, the sequence of steps utilized in the illustrative flowcharts are examples and not the exclusive sequence of steps possible within the scope of the present invention. Similarly, data structures other than the ones mentioned herein may be used to hold data without departing from the scope of the present invention.